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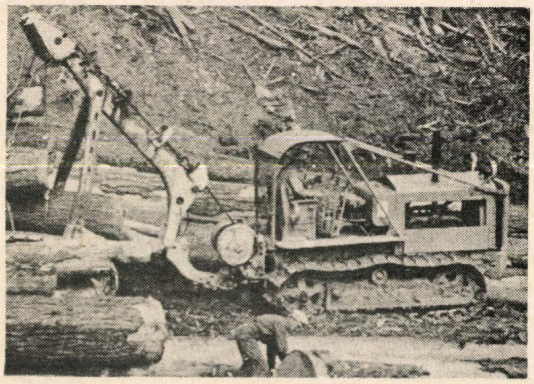
NORTHEASTERN LOGGERS' HANDBOOK

by

Fred C. Simmons

PRELIMINARY REVIEW EDITION



Easier and Safer Work

Greater Production (more pay) and Better Living Conditions

SECTION 17:— ALL WEATHER ROADS

NORTHEASTERN FOREST
EXPERIMENT STATION

United States Department of Agriculture

FOREST SERVICE

NORTHEASTERN FOREST EXPERIMENT STATION

614 Bankers Securities Building
Philadelphia 7, Pennsylvania

V. L. HARPER, DIRECTOR

FOREST UTILIZATION SERVICE
James C. Rettie, Chief

If you want to be a mechanic, you will easily find plenty of good books which will tell you what you need to know. You will also find plenty of instructors and training shops.

What about the young man who wants to make his living by logging? For him there is no good source of information to which he can turn. The books and courses on logging are for the logging engineers—not for the fellow who uses the axe and crosscut.

Why shouldn't there be a simple illustrated handbook which will tell the young woodsman (or the green woodsman) what he needs to know about the care and use of his tools and the best of the old and the new techniques of, and devices for logging? He needs to know the "tricks of the trade" as much as anyone.

We hope that these pages, together with other short papers like it, will finally be put together in a printed NORTHEASTERN LOGGERS' HANDBOOK. We are putting it out in this form first because there seems to be an urgent need for this sort of information; and because we need the help and advice of persons who know about logging in our region before printing. We want the experienced logger to tell us what important things we have missed and where our advice is not good. We want the young man going into the woods for the first time to tell us what parts of it he finds hard to understand, to suggest how it can be made more useful to him. We would like the equipment manufacturers to check our recommendations for use of their products and tell us about new devices they are developing.

Please send criticisms, questions and suggestions to: The Director, Northeastern Forest Experiment Station, 614 Bankers Securities Building, Philadelphia 7, Pa. Additional copies of this and other publications in this series can be obtained from the same address.

1947

SECTION 17

CONSTRUCTION OF ALL-WEATHER ROADS

By Fred C. Simmons*

The trailbuilder or angledozer and the motor truck are changing timber-hauling practice in the Northeast. These, along with other new equipment, have made it possible to build woods roads at low cost and to use them at all seasons of the year. This has made hauling much less a seasonal job. The loggers say, with typical exaggeration, that there will soon be a road to the foot of just about every tree. Better public roads which are kept open all winter have also been an important contributing factor. All-season hauling makes possible steadier work for the men in the woods and in the wood-using plants. The flow of raw material continues throughout the year. This is desirable from almost every standpoint.

Angledozer building logging road.

This Section deals with the building of logging roads, but only of the roughest low-service dirt and gravel types. Construction of the higher types of road, such as those built by township, county, or state authority, is an engineering subject much beyond the scope of this handbook.

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* Specialist on logging and primary processing, Forest Utilization Service, Philadelphia, Pa.

In the preparation of this Section the author has drawn freely on the "Truck Trail Handbook" of the U.S. Forest Service.

Planning a woods road

Deciding on the amount of road to build, the general location, and the standard of the road is often a difficult economic problem. Whether it is better to extend a road into a specific block of timber and truck the timber out, or to skid the timber to some existing road depends on the cost of the new road and the cost of trucking over it. Extra wear and tear on trucks hauling over a rough road will often balance against any saving on costs of skidding. On the other hand, if the logs should be clean when delivered to the mill, ground skidding should be held to the minimum. The problem of loading the trucks in the woods is important.

After the decision to build has been made, the job of road location begins. This is usually given to the logging superintendent.

Quite often the cheapest road to build would go right up the stream bottom. This, except for the most temporary roads, is not the location to choose. Spring and fall high water will often take out such a road or make it impassable until costly repairs are made. There is always the chance that a downpour of rain will take it out at any time.

In some instances a ridgetop road is the cheapest and the easiest to maintain. This, however, may not be practicable if it means expensive uphill skidding to get the logs to the road.

A sidehill location, near but safely above the stream bed, is usually the best location. It permits downhill skidding and it usually taps the heaviest part of the timber stand. The disadvantages lie in the amount of earth that must be moved in the grading, the probability that some rock work will be required, the necessity for adequate drainage facilities, and the possibility that slides may occur.

A single-track woods truck road should be at least 10 to 12 feet wide with curves and turnouts considerable wider. A two-track road should be 18 to 20 feet wide. These minimum widths apply to the more difficult ground. Where the road is on a gentle slope, on level ground, or on a fill it could well be somewhat wider.

A road to be travelled by nothing heavier than a 1-1/2 ton truck with single rear axle should have no curve sharper than a 25-foot radius. Whenever possible, without undue cost, even the lowest standard road should have curves with greater sweep than this. An 80-foot radius is much better for any road to be travelled with heavy loads. Where an "S" curve cannot be avoided, there should if feasible be a tangent of at least 50 feet between the two curves.

Drainage is one of the major problems of the woods road locater. He should avoid bogs or flats, slopes that have many springs and seeps, and crossings of flashy streams at points where the channel is not well established.

Maximum grades in the road are controlled by the character of the ground and the kind of trucks that are to be used. Uphill grades of 10 to 12 percent (vertical rise of 10 to 12 feet in 100 feet of road) can be negotiated by modern trucks if not overloaded. Downhill grades of 15 percent can be tolerated for short distances. Anything steeper than these grades is likely to be very hard on trucks and somewhat dangerous.

In building temporary logging roads, methods can often be used that would be quite unacceptable in building permanent roads. Boggy places, for example, can sometimes be crossed on earth-covered corduroy that everyone knows will rot out in a few years. Timber stringers on earth abutments may be good enough for some of the bridges which will be needed only for a year or two. Rotten wood can be used to cover rocky places. Plank roads or portable plank mats can be used in some of the bad sections when rain or some other condition makes them otherwise impassable.

The extent to which the road should be improved depends upon how much traffic it must carry, how long it will be used and whether it should serve later for another cut of timber or for fire control or such purposes.

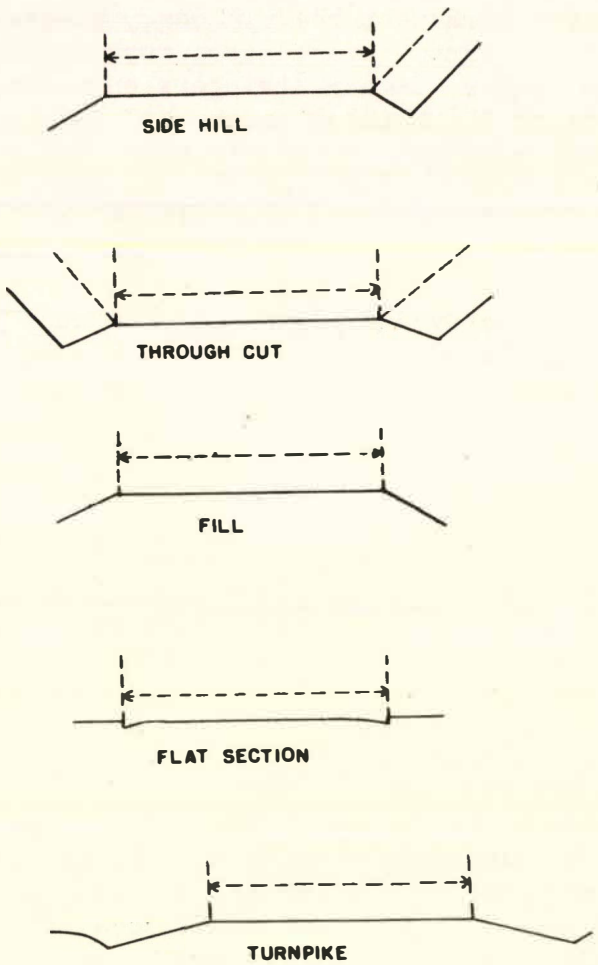
Locating the road

The detailed location of the road is much too important to be left to an inexperienced foreman of a construction crew. This has often led to costly mistakes--curves too sharp, drainage problems disregarded, poor alignment and grade, etc. Faults like these mean slow travel, undue wear on equipment, expensive maintenance, and too many accidents.

If the ground is reasonably smooth and the slopes are gentle, the quantities of earth to be moved are not very large. The balancing of cuts and fills can be done without resort to surveys. In places where slopes are steep and difficult, and considerable cutting and filling is necessary, it is well to apply some simple engineering methods. This involves making a rough profile and calculating the balances of earth to be removed from cuts and placed in fills. This will save some of the cost of borrowing and hauling for fills or of digging and wasting soil from the cuts.

Good cross sections for a number of different conditions are diagrammed here. On hill sides, and through cuts and fills, the pitch of the

roadside slopes should vary with the type of soil. Normally a slope of one foot rise in each foot of horizontal distance is reasonably safe from slips and cave-ins. In some types of soil even steeper side slopes can be trusted. Where slipping is to be expected, and a safe slope is too costly, log cribwork or stone rip-rap can be used to restrain sliding earth. "Turnpiking", merely casting up material from the roadside ditches to form the road surface, is good practice in gravel or sandy soils. Where the material from the ditch is unsuitable for surfacing because it is too high in organic matter, clay, or the like, it should be cast aside and surfacing material should be hauled in.



Typical cross-sections for logging roads.

The survey work can be done with an abney level and topographic steel tape. The following set of instructions may be helpful:

1. Run a preliminary grade line from the highest point in the proposed road down to the valley. Use less than the average grade to allow for adjustments. If the average grade is 8 percent this preliminary contour should be 7 percent. Measure the side slope of the ground at each grade point and mark it with a stake.

2. Run a compass-and-tape traverse between the grade points. Locate all features (such as heavy rock work, springs, marshes, heavy clearing) that are near enough to the grade line to influence the choice of final location. On difficult sections it may be desirable to map the contours.

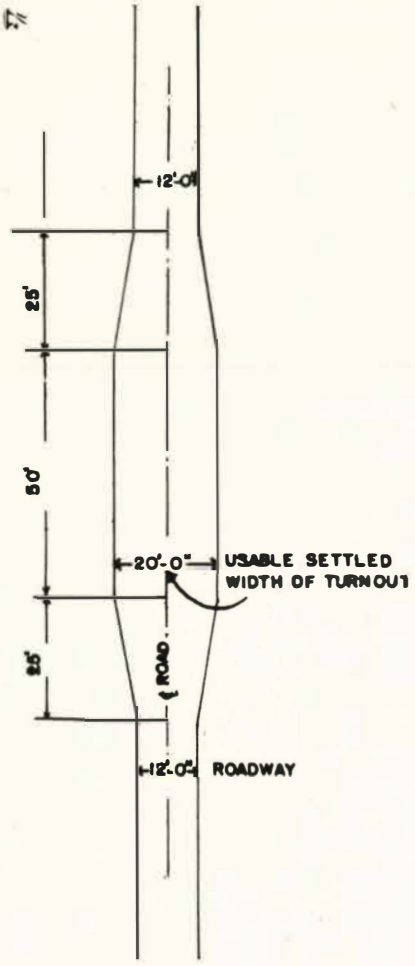
3. Plot a map of the preliminary grade line showing location of each grade stake, side slope at each grade stake, location of all features which will cause heavy work, contours if needed.

4. Draw a proposed location line along the grade line. The amount of cut or fill at any point on the location line can be calculated from the side slope and the scaled distance between the preliminary grade line and the location line. Some cutting and filling can be avoided by taking advantage of moderate undulations in the grade.

5. Locate the curves on the map. Show the radii, center angle, and external distance to help in running the curves on the ground.

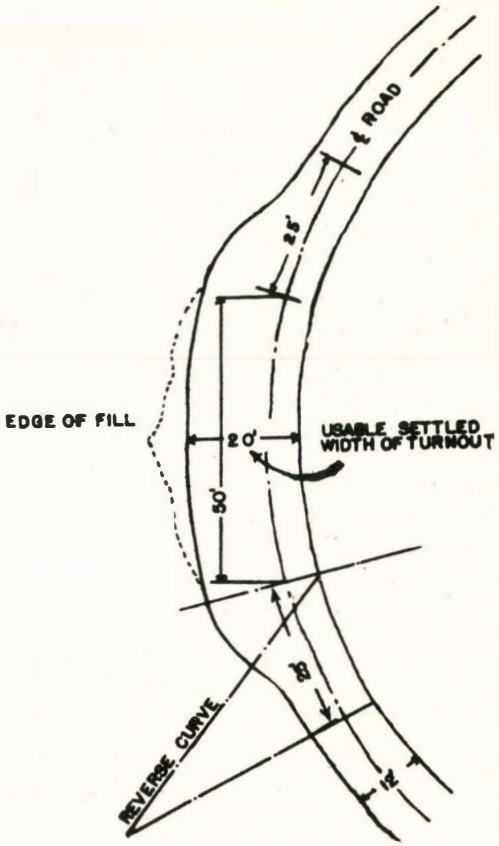
6. Locate the final line on the ground by measuring from the preliminary grade line stakes. The distance to measure from the stakes can be scaled from the map.

Remember that with the exception of rock, excavated material in a fill shrinks during settlement. A 25 percent shrinkage and loss is about normal for light cuts and fills. Rock expands from 40 to 60 percent, depending on the size of the fragments. If the fill is a mixture of rock and earth the percentage of expansion is smaller.



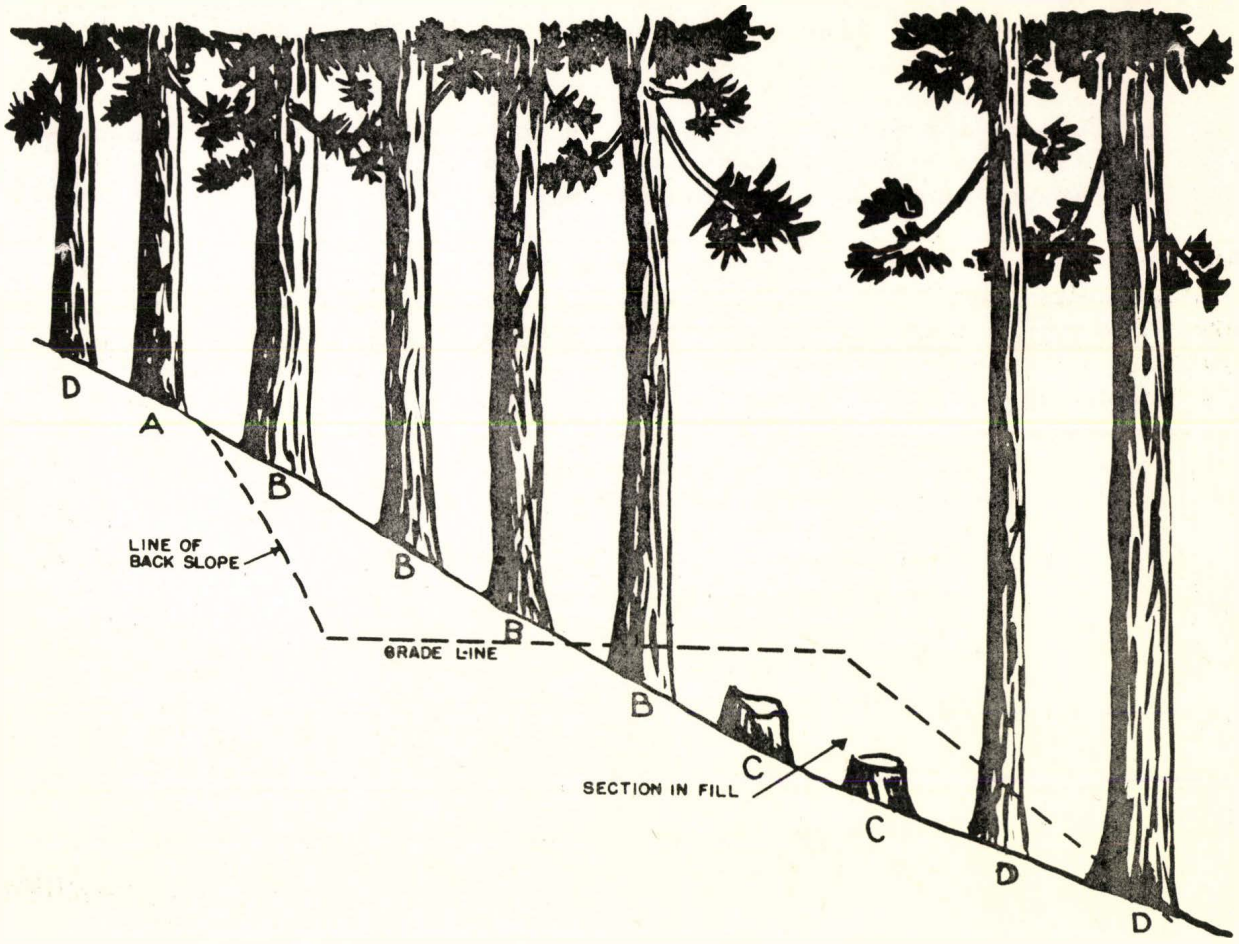
On one-way roads turnouts should be staked in order to provide for proper width and length, and to avoid unnecessary excavating. Full advantage of natural features should be taken in placing turnouts. They are particularly necessary on or near blind curves or at the top of any steep pitch where the road beyond is not in view.

Use of a technically trained engineer or forester in locating and staking logging roads would save many northeastern loggers considerable of the cost of road construction and maintenance



Clearing

A diagram showing the amount of clearing recommended for a woods road is shown here.

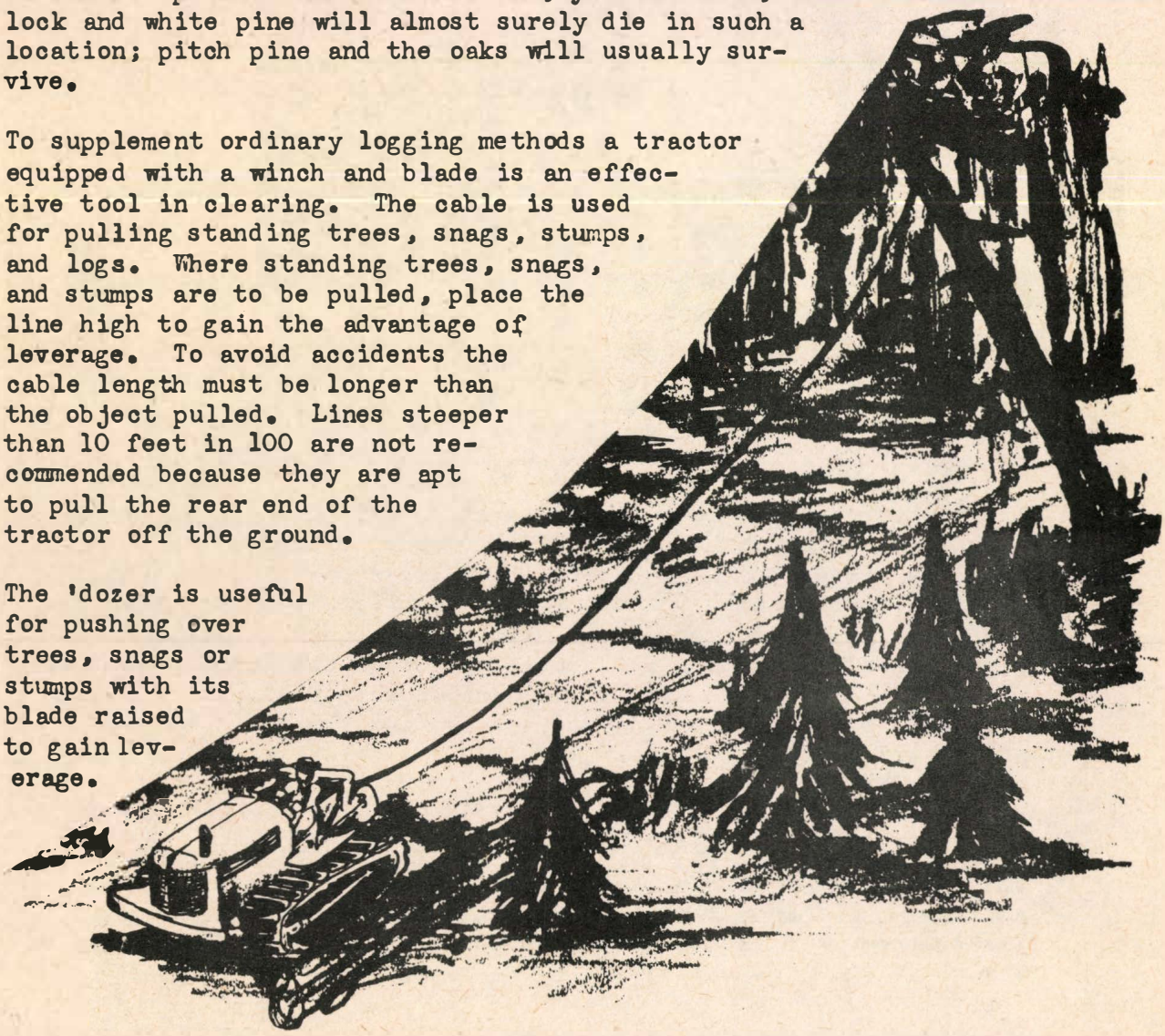


The trees marked "A" can be left or cut, according to their species, amount of cut or fill, and type of soil. Trees at the top of the slope, when many of their roots are cut, are apt to die or to slip into the road. Those at the bottom will also die if a fill of

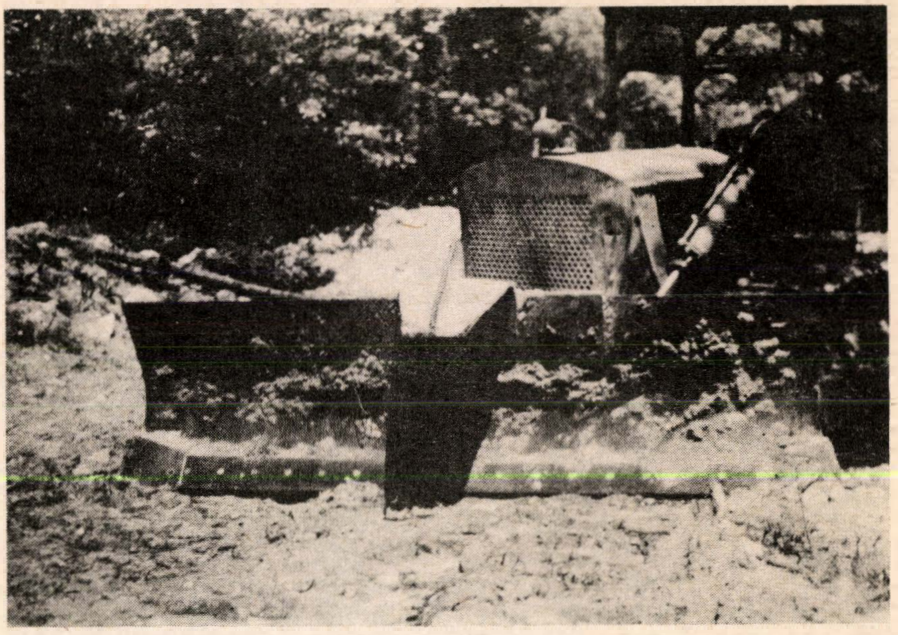
impervious earth is allowed to build up around their bases. Trees marked "B" should be removed, roots and all. Those marked "C" can be cut, and their stumps left to aid in holding the fill in place--providing their tops will not be within a foot of the final road surface and they are of rot-resisting species. Stumps which rot easily should be removed to prevent troublesome settlement and holes in the road surface. Trees marked "D" within 3 feet of the cut or fill line can be left uncut providing they will not interfere with road maintenance equipment or with vision on the finished road. Only the species known to be tough should be left. Species such as white ash, yellow birch, hemlock and white pine will almost surely die in such a location; pitch pine and the oaks will usually survive.

To supplement ordinary logging methods a tractor equipped with a winch and blade is an effective tool in clearing. The cable is used for pulling standing trees, snags, stumps, and logs. Where standing trees, snags, and stumps are to be pulled, place the line high to gain the advantage of leverage. To avoid accidents the cable length must be longer than the object pulled. Lines steeper than 10 feet in 100 are not recommended because they are apt to pull the rear end of the tractor off the ground.

The 'dozer is useful for pushing over trees, snags or stumps with its blade raised to gain leverage.



An inverted L-shaped pusher bar welded on the blade gives additional height and leverage. After the object is partially over the 'dozer blade can be caught under the roots and the lifting action of the blade used with the push of the tractor. A substantial guard would be needed to protect the tractor operator.

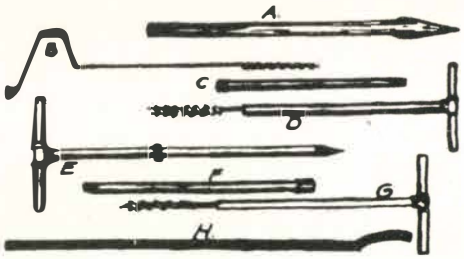


Tree dozer

Explosives are also useful in clearing. With them it is possible to get out trees which cannot be removed otherwise without great trouble. Large stumps that cannot be loosened with the tractor can be broken up with a shot or two; and the pieces can then be handled with the 'dozer blade. Large trees such as hemlock and fir, with spreading surface roots, can frequently be blasted down without cutting. The tap-rooted species should always be cut first. A slow-burning dynamite is best for blasting stumps. A primer and electric blasting machine is a surer and safer way to set off the charges than with a fuse.

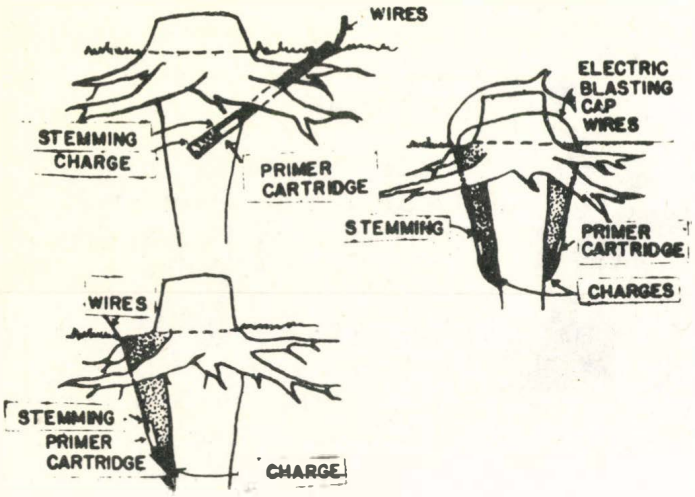
Explosives can also be used to loosen trees on side slopes too steep for maneuvering with the tractor. Such trees can be cut, and then the stumps can be shot just hard enough to split and loosen them. It is not necessary to shoot them out clean, since the split stump can easily be taken out at the time grading is done.

Blasting Stumps

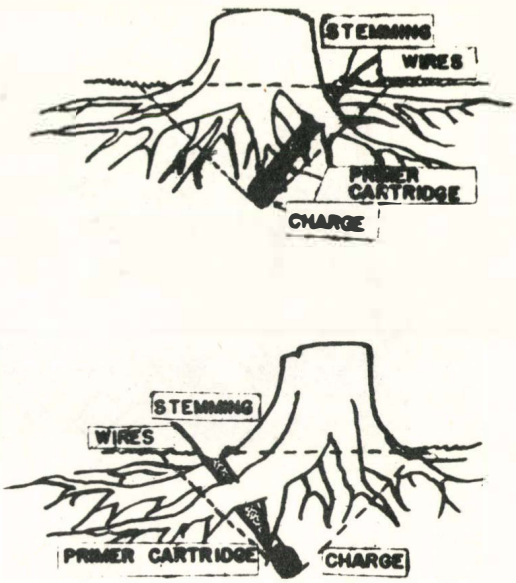


STUMPING TOOLS

A - Steel striking bar
B - Wood augur - crank handle
C - Extension for wood augur D
D - Wood augur - T handle
E - T punch bar
F - Extension for soil augur
G - Soil augur
H - Tamping stick (shovel handle)



Charges for tap-rooted species



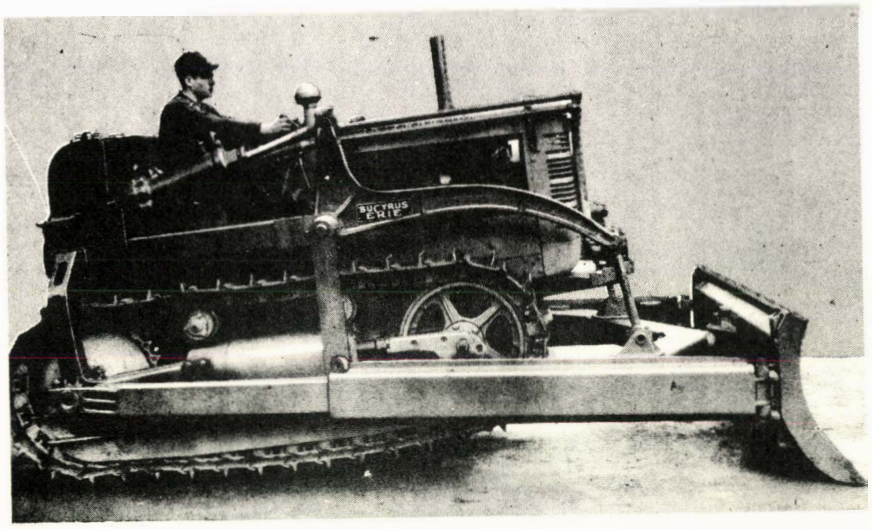
Charges for lateral rooting species

Clearing road rights of way, whether or not explosives are used, is one of the most dangerous jobs in the woods. The safety precautions stressed in Section 8, "Pointers on Felling Trees" and Section 11 "Skidding with Tractors" apply to this job with extra force because often a number of crews are working close together. Use of explosives will increase the hazards and a good and strictly enforced warning system is a necessity.

Earth excavation

Great improvements in equipment for all kinds of earth-moving jobs have been seen in recent years. Units that are particularly suitable for building rough roads are briefly described here.

A favorite piece of equipment is the "trailbuilder", also called the "angledozer". It consists of a standard crawler-type tractor, in the medium or heavy sizes, equipped with a heavy steel "dozer" blade mounted across the front of the machine. This blade can be raised or lowered by hydraulic or cable devices and each end can be advanced or retracted to change the angle of the blade. It is thus possible to push earth to either side as the tractor goes forward.

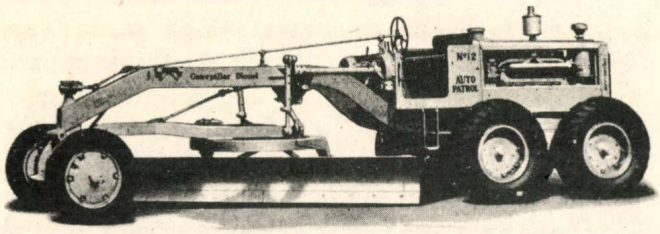


"Trailbuilder" or "Angledozer"
(Hydraulic control)

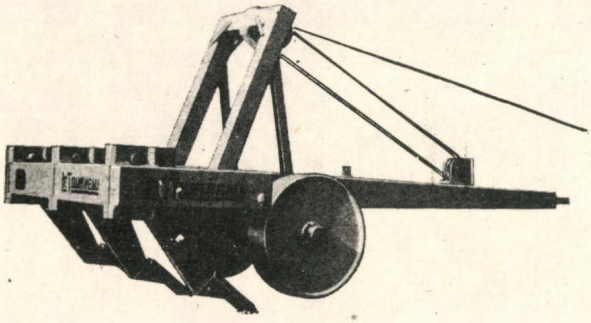
This machine is suitable for the pioneering work on slopes which exceed 30 percent. The excavation should be started as near the top of the cut line as possible and following the cut line by dropping down somewhat on each successive cast. An experienced operator by proper spacing of his cuts can make a satisfactory bank slope with the trailbuilder. This method is highly desirable because a vertical bank on the upper side of a grade can otherwise be given the necessary slope only by expensive hand work. Boulders and rock ledges in the bank must, of course, still be handled by other means.

The trailbuilder is most useful in work that requires a short end-haul and accurate placing of the material being moved. It is not efficient when run along the road like a grader. Its best use is in digging and sidecasting in a short arc with a minimum of steering. For best results the machine and blade should be kept as level as possible. It is especially useful for cutting extra widths in the road for curves and turnouts. For work on soft or muddy ground the machine with a hydraulically-controlled blade is best. This mechanism can apply downward as well as upward force to the blade. If the machine gets stuck in the mud, it is usually possible to raise the front end of the tracks by down-pressure of the blade on poles or small logs laid under it. It is then possible to lay poles crosswise under the tracks to give flotation. The blade is then raised and the tractor moves out under its own power.

For straight grading work after the pioneer cut has been made or on gentle slopes that are not too rocky, the tractor grader is the best implement. This is the familiar self-propelled machine often seen at work on the public highways. It is strictly a side-casting tool. It can be used as the pioneer tool on slopes less than 30 percent if the ground is smooth and free from large boulders. For this kind of work the mold-board should be set at an angle of 15 to 30 degrees from the center line of the grader. Loggers frequently find it worthwhile to rent these machines, but many of them are forced to use the angle dozer for work that should be done by the grader.



Tractor-grader



Ripper

"Hardpan" and rocky ground that cannot be handled with the trailbuilder or the grader can be loosened with the "ripper". This is a heavy set of spike teeth that are pulled behind a tractor. The heavier types for use with a 60- or 90-horsepower tractor will often loosen hard and rocky ground at less cost than would be involved in blasting.

Rippers with three teeth are best for the hardest ground. Those with five are good for uncovering smaller stones preparatory to finishing the roadbed.

The power shovel with dump trucks is almost a necessity in making large fills where the material must be hauled from cuts or borrow pits some distance away. For economy it is essential to have enough trucks to keep the shovel busy. Power shovels are also good tools for heavy side cutting. If the job is sufficiently large a power shovel may prove to be more economical for this work than the trailbuilder. The "carry all" type of earth mover is an economical alternative to a shovel and trucks where reasonably short hauls are involved.

Rock excavation

It is often possible to remove rock by using a heavy tractor and ripper. Blasting often shakes up the country and causes slides. Sometimes a seam in a rock ledge can be shot, and the loosened rock can be handled with trailbuilder and ripper.

Where the rock is too hard for such methods it has to be handled with explosives. Often there is a considerable overburden of dirt or gravel which must be stripped off. The trailbuilder is good for this purpose. When all material that can be handled by the equipment has been removed, the stripping should be finished by hand to expose all seams, crevices and other rock formations which may help in spotting drill holes to break the rock. Sometimes it is advisable to have an experienced "powder man" go over the job, barring and shooting loose rock and seams as much as possible. This will reduce the drilling and get rid of loose rock, which is always a danger in blasting.

Hand drilling is slow and expensive. Most big logging concerns have purchased compressor and pneumatic drill outfits. Smaller logging operators can frequently rent such equipment. There have recently been placed on the market, however, several small portable rock drills, powered by a self-contained gasoline motor. These should be very useful in logging work.

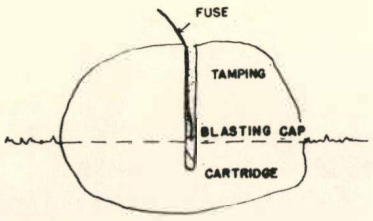
Gasoline Rock Drill

Economical shooting of rock and thorough breakage can be obtained only through correct depth and placement of drill holes which have been properly loaded with the suitable amount of the correct explosive. An experienced powder man, who knows the local rock conditions,

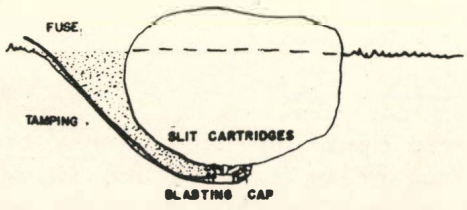
is almost essential for economical and efficient work. No definite rules or formulas will fit all drilling conditions. The spacing between the holes in a row along the back slope should average about three-fourths the total depth. Where nearby improvements prevent heavy shooting, or where it is desired to keep a large amount of rock on the slope, closer spacing is necessary.

The type of explosive to be used depends on the type of rock being shot, and the results desired. High-velocity explosives produce the best shattering effect. Low-strength explosives, such as are recommended for stumping, produce the best loosening or propulsive effect. Other characteristics to consider are resistance to moisture and freezing, and sensitiveness and velocity.

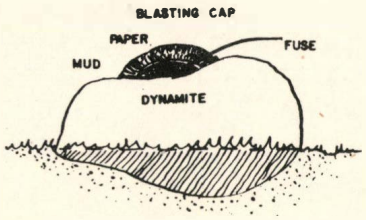
After blasting it is necessary to break up rocks still too big to be handled by the equipment available. Blockholing or mudcapping can be used for this. Boulders 4 feet and over in diameter should usually be handled by blockholing if a rock drill is available. Diagrams showing recommended methods for shooting such rocks are given below:



Blockholing



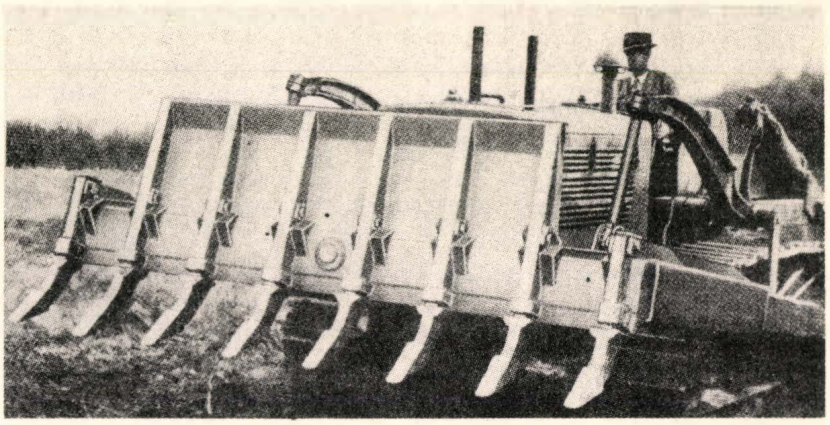
Snakeholing



Mudcapping

Methods of shooting rock

A rock blade in place of the 'dozer blade will make it possible to push out the heavier rock with the tractor and save the finer material for the road surface. Such a blade has scarifier teeth on its lower edge. It costs about $400 and should be standard equipment on all jobs where considerable rock excavating is to be done.



The tractor and winch can be used to considerable advantage in removing and placing individual large boulders that cannot be handled to advantage with the blade.

Rock excavation should usually be carried to a depth of at least 12 inches below the level of the final grade, and should be backfilled with suitable material for a cushion. This will prevent uneven surface and consequent racking stresses on the trucks as they pass over the road.

Finishing

The money spent on providing a good wearing surface may easily be the most productive expenditure in making a logging road. As a general rule the best shaping is that which will result in a minimum of surface wash and ruts. If ruts are unavoidable they should be shallow and of even depth. Care should be taken to bank the curves in the right amount and direction, to avoid excessive inslope or outslope, and to give the road the proper crown. The grade should be thoroughly worked over with a ripper, removing all rocks and roots that will not provide a satisfactory wearing surface. Thorough ripping will also cause the finished section to compact more evenly. If there is an excessive amount of large loose rock a trailbuilder with rockblade attachment should follow the ripper, moving the rock off the road.

Surfacing

On many roads the addition of surfacing material will be economically justified. The soil in which the road is built may not be suitable for wear or drainage. Clay, for example, ruts easily when wet; and when dry it has a china-like hardness and is practically impossible to

grade. It is also very slippery when wet. Addition of a 3- to 4-inch porous layer of sand or gravel helps considerably.

Peats and mucks are the most unsatisfactory types of soils. They shrink and expand up to 50 percent in wetting and drying. The best method of improvement is to add coarse granular material. The various loams contain a percentage of sand, and are considerably better as road materials. They may dry to form clods, but these can readily be broken up. Some addition of sand is, however, often desirable. A pure sand or gravel soil can often be improved by the addition of clay or loam which will help keep it in place. The objective, as in mixing concrete, is to fuse the fine and coarse material into a surface that has moderate plasticity, that will drain well, that can be easily graded, and that will stay in place under traffic. The addition of calcium chloride or waste sulfite pulpmill liquor will often cut down on dust raising in dry weather, and on washing in wet weather.

Drainage

One of the chief factors affecting the life and serviceability of any type of road surface is the amount of moisture in the subgrade and surfacing. If side ditches are not adequate, flow or water on or across the road not only washes away material but decreases the road's stability.

Crown is important for adequately draining the road surface. The maximum crown recommended for areas of heavy rainfall is:

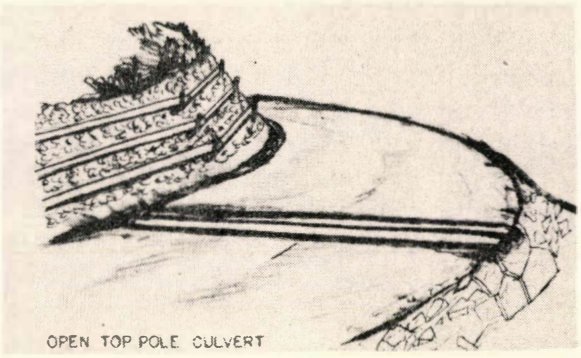
Grade (Percent)	Height of crown at center: 9-foot width (Inches)	Height of crown at center: 16-foot width (Inches)
0 - 5	2-1/4	4
5 - 10	1-3/4	2
10 and over	1-1/4	2

If crown is inadequate, in the subgrade as well as the wearing surface, water will collect, and the road will become pitted under traffic.

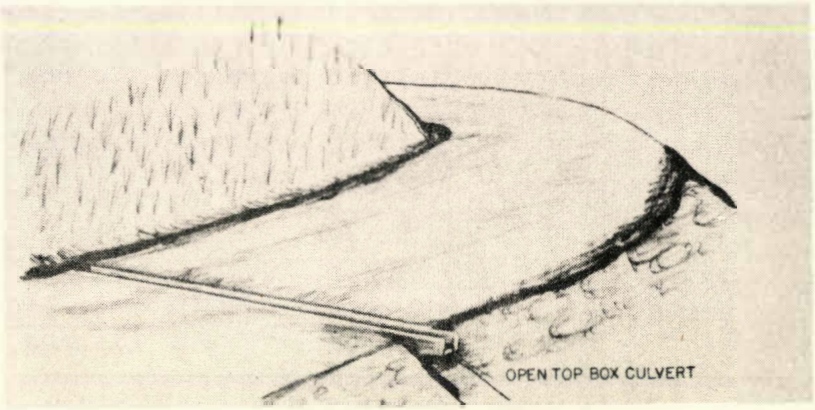
The entire surface of the road may be sloped toward the cut bank to prevent erosion, or as a safety precaution on slippery soils. An insloped road needs additional culverts except where the road material is so pervious that water will seep through it. Water should not be allowed to accumulate in large quantities on the uphill side of a

road or on its surface. Culverts, either open top, or closed, or bridges should be installed where needed to carry this water across the road.

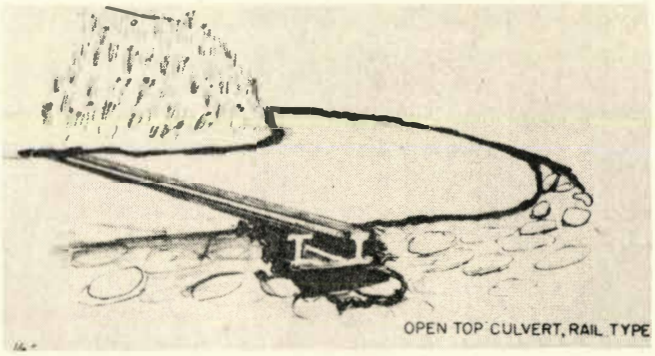
Open top culverts are particularly valuable since they are cheaply constructed and installed and carry off road surface as well as roadside ditch drainage. Three good ones are sketched below



OPEN TOP POLE CULVERT



OPEN TOP BOX CULVERT

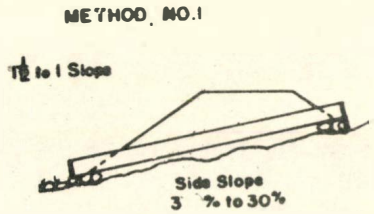


OPEN TOP CULVERT, RAIL TYPE

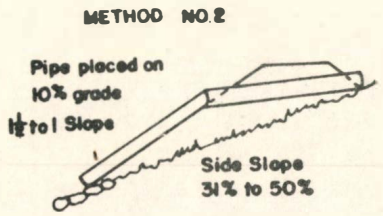
Closed-top culverts are most commonly installed. Many types are used. Where large durable flat rocks can be readily obtained for a cover, stone culverts may be most economical. Masonry walls should be built up on a solid foundation. The top of the culvert should be at least 12 inches below the road surface. For temporary installations split round or sawed native timber may be satisfactory. Slabs and poles may also be used to make an effective culvert.

Galvanized, corrugated iron pipe is probably the most popular culvert material. On woods operations, where the water may be quite acid, such culverts should be protected against corrosion on the lower side with a bituminous or asphalt coating. Otherwise the pipe may not have a much longer life than untreated wood. Corrugated pipe has the advantage that it can be easily spliced to lengthen it. This makes it possible to lengthen it at any future time if a wider road is desired. The proper method of installing corrugated pipe is illustrated below.

Manufactured reinforced concrete pipe is available in many localities at a price competitive with galvanized iron. It is, however, heavier and more expensive to move. Where soil conditions corrode the iron pipe quickly the concrete pipe may be economical even at a higher price.

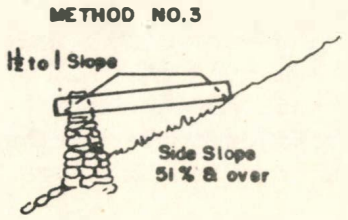


Asphalt impregnated paper or asbestos pipe is becoming available in large sizes. It is relatively permanent, strong, resistant to acids, and can easily be lengthened. It is being used for the smaller culverts.



Vitreous tile pipe is rarely strong enough for heavy-duty logging roads.

Corrugated metal pipe arches are especially useful for shallow fills and limited headroom. They are as strong as round corrugated culverts, and require no special foundations.



They are particularly valuable for use in place of bridges in carrying small streams under the road.

Natural water courses are excellent places to install culverts, since the inlet and outlet will require no special construction. In many cases, however, culverts will be necessary where there was no water course before. Culverts should be installed on a gradient of not less than 3 percent. Where a great deal of silt is to be carried a much steeper gradient, up to 20 percent is desirable. A good rule to follow is to install any culvert on a slope that is 2% greater than the grade of the road above it.

The trench for pipe culverts should be prepared with the bottom on even grade and free from rocks that would injure the pipe when the fill load is applied. Galvanized pipe is easily dented or bent by careless handling. This spoils the rust-preventative coating.

In fills where settling is expected the culvert should be slightly raised at the center, so that there will not be a sag in the middle when settling is completed. The back fill should be carefully tamped to give a firm support to the lower half of the culvert.

Headwalls and inlets on culverts should be so constructed that the entering water will not cause the ditch to erode or the cut bank to slough into the intake and thus plug the culvert. Outlets should be so located that the released water will not undermine the fill. To prevent such erosion it may be necessary to pave a trough or spill platform of rocks from the end of the culvert to solid ground.

Many small streams can be carried under the road by galvanized iron culverts, which are available in capacities up to 36 and 48 inches. Where one culvert is not enough to carry the water two or more can be placed close together. They should not be, however, closer than half their diameter.

Bridges

Where a culvert will not carry the water a bridge becomes necessary. The most common bridge is the simple timber stringer type, usually erected on timber cribwork abutments. A diagram of such a bridge is given on the next page.

Timber crib, timber stringer bridge

For a tempoarary bridge, earth abutments may suffice provided the stream bank will not fail. Such bridges may be built from almost any sort of timber that is locally available. Bridges to be used a longer time should be more carefully planned; they should have firmer foundations and should be made of more durable timber. The more durable species available in this territory are white oak, black locust, cedar, chestnut oak, and tamarack. Somewhat less durable are beech, birch, hemlock, sugar maple, red oak, spruce, and yellow poplar.

Wherever possible the bridge should be built where the stream has a straight unobstructed channel that is well established. The bridge should cross the streambed, if possible, at right angles rather than on a skew. If a skew crossing cannot be avoided the abutments and piers should be set approximately in the direction of the stream flow in order to avoid disturbance of the water and scouring of the banks.

The bridge should be high enough so that it will clear flood crests by enough distance to avoid being caught by floating logs and other drift. Five feet above maximum flood level is none too much. The abutments should be far enough apart so that they will not constrict the channel, even in flood time, to cause an increase in water velocity that may undermine them.

The following table, compiled by the U. S. Army Engineers, gives a simple but reasonably accurate method of determining the safe gross load capacity in tons of timber stringer bridges per inch of stringer width:

Depth of Beam in Inches

Span in Feet	6	8	10	12	14	16	18	20	22	24
10	.19	.34	.55	.80	1.05	1.40	1.75	2.15	2.65	3.15
12	.15	.28	.44	.65	.90	1.15	1.45	1.80	2.15	2.60
14	.13	.24	.37	.55	.75	.95	1.25	1.55	1.85	2.20
16	.11	.20	.32	.47	.65	.85	1.05	1.30	1.60	1.90
18	.10	.18	.28	.41	.55	.75	.95	1.15	1.40	1.70
20		.16	.25	.36	.50	.65	.85	1.05	1.25	1.50
24		.11	.19	.27	.38	.50	.65	.80	.95	1.15
28		.09	.15	.22	.32	.42	.55	.65	.80	.95

Example: Determine capacity of one-lane bridge which has six 8"x10" wooden stringers over a span of 18 feet. Value from table using 10" and 18' is .28. Total stringer width 6x8 or 48 in. .28x48 is 13.4 or 13 tons safe capacity.

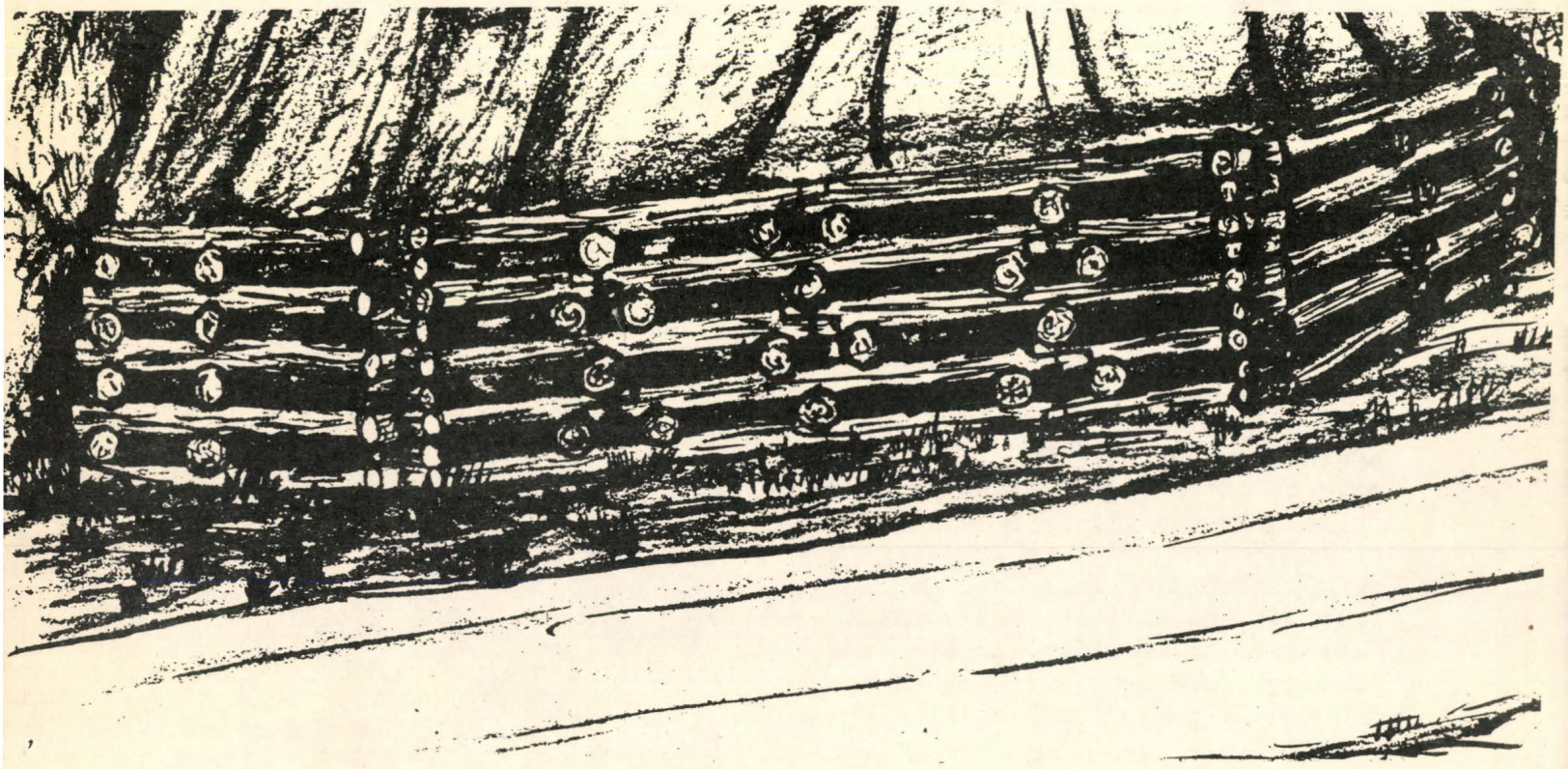
For stringers of round timber use diameter of timber as depth and 0.4 of diameter as width and use above table.

For two-way bridges count stringers only on one side.

Flooring should be once-and-a-half as thick in inches as distance between stringers in feet. For instance, if stringers are two feet apart flooring should be 3 inches thick.

Cribwork for Bridge Abutments and Retaining Walls

For dirt or gravel slopes too high, or too full of seeps for economical backsloping, a rock wall or timber crib retaining wall is often the most economical way of holding the slope in place. Such retaining walls are frequently installed both on cuts and fills. A sketch of a typical timber crib is given below:



If the road is to be used for any length of time it is wise to use timber species resistant to rot in such cribworks. The tie logs, at right angles to the surface of the crib, should be at least 8 feet long, and buried in the bank. Old railroad ties which have been treated with

creosote or some other preservative at the time of their original installation are frequently a convenient source of rot resistant timbers. Such ties will usually last longer than all but the most rot-resistant local species cut and installed green.

Road maintenance

Regular maintenance of dirt roads is essential, if hauling costs are to be kept within reasonable bounds. Much of this maintenance is necessarily done by hand. Even though they have been installed correctly culverts will sometimes become plugged up, and have to be cleaned out. Washes, land slips, and rock slides will occur. For many of these maintenance jobs the bulldozer is a good tool, but for regular work, over the entire road, a tractor grader or motor patrol is almost a necessity. These machines can sometimes be rented from a local contractor or local nonfederal government authority. Lacking a grader a road drag made of old railroad rail, can be hauled behind a truck or tractor to do some of the necessary maintenance, but much more hand work will be necessary to supplement its efforts.

Tramways

In recent years there has been a revival of interest in tramways, or small independent railroads among Northeastern timber operators. This has been brought about by the availability of light powerful diesel and gasoline powered locomotives, commonly used in the mines. One operator in West Virginia claims that the cost of installing a narrow gauge tramway, in rough country, averages only about $600 a mile, as against a cost of $1500 to $2000 a mile to build almost any type of road. Frequently the ties are laid on stringers of cull logs across soft or swampy ground. Simple cribwork trestles are built to carry the tramways over rock cliffs and streams. Ties are sawn from cull material, and are laid about 18" apart. Uphill hauls of up to 15% are negotiated with loads of three to four thousand feet of logs. One operator uses two log cars, one in front of and one behind the locomotive. When a steep pitch is encountered the back car is uncoupled and the front car is pushed up the slope. Then the locomotive goes back for the other car.

Diesel locomotive and load of logs